

A Decision Support System for Monitoring, Reporting and Forecasting Ecological Conditions of the Appalachian National Scenic Trail



University of Rhode Island

Y.Q. Wang, Pete August, Roland Duhaime, Chris Damon, John Clark, Fu Luo, Jianjun Zhao, Chuck LaBash, Peter Paton

NASA Ames Research Center

Rama Nemani, Forrest Melton, Hiro Hashimoto, Sam Haitt

National Park Service

NETN: Fred Diffenbach, Brian Mitchell
APPT: Matt Robinson, Casey Reese

US Forest Service

Ken Stolte

USGS

Glenn Holcomb, Marcia McNiff

Appalachian Trail Conservancy

Paul Mitchell

A.T. is a cross-section MEGA-Transect of the eastern U.S. Forests and alpine areas, and offers a setting for collecting data on the health of eco-systems for early detection of undesirable changes in the natural resources.



Appalachian Trail:

2,175 miles (3,500 km) long and crosses **14** states in the Eastern U.S.

Intersecting **8** National Forests; **6** units of the National Park System,

More than **70** State Park, Forest, and Game Management units, and **287** local jurisdictions

The protected lands harbor rare, threatened, endangered species

Science and Management Questions:

- What is the spatial distribution of RTE species, and are distributions shifting?
- What are the trends in the geographic extent and distribution of invasive species?
- What is the geographic distribution of forest and high-elevation vegetation communities and how are they changing?
- What are the trends in land-cover, land-use change, and landscape dynamics, and their relationships to key resources and human activities?
- How is climate change impacting the geographic distribution, composition and phenology of high-elevation, summit, and ecotonal species?
-

Objectives

1. Develop a comprehensive set of seamless indicator data layers consistent with selected A.T. “Vital Signs”
2. Establish a ground monitoring system to complement TOPS and integration of NASA data with *in situ* observations
3. Assess historical and current ecosystem conditions and forecast trends with connection to habitat modeling
4. Develop an Internet-based implementation and dissemination system for data visualization, sharing, and management to facilitate collaboration and promote public understanding of the A.T. environment.

Lessons Learned and Recommendations

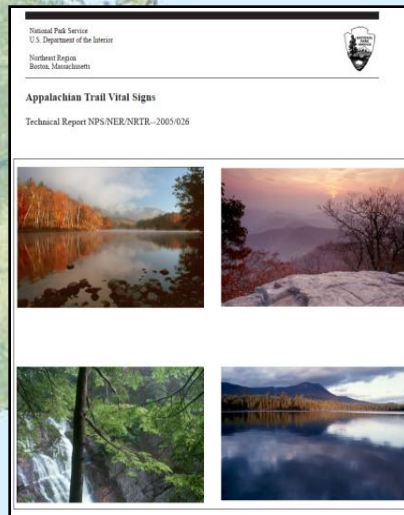
1. Allocate sufficient time to develop a genuine science–management partnership
2. Communicate results in a management-relevant context
3. Conform or embellish existing frameworks and processes
4. Plan for persistence and change
5. Results should be expressed using formats and language familiar to managers and connections should be made between results and attributes that affect decisions.

Vital signs are defined as a subset of physical, chemical, and biological elements and processes that represent the overall health or condition of different natural resources.

NPS I&M Network

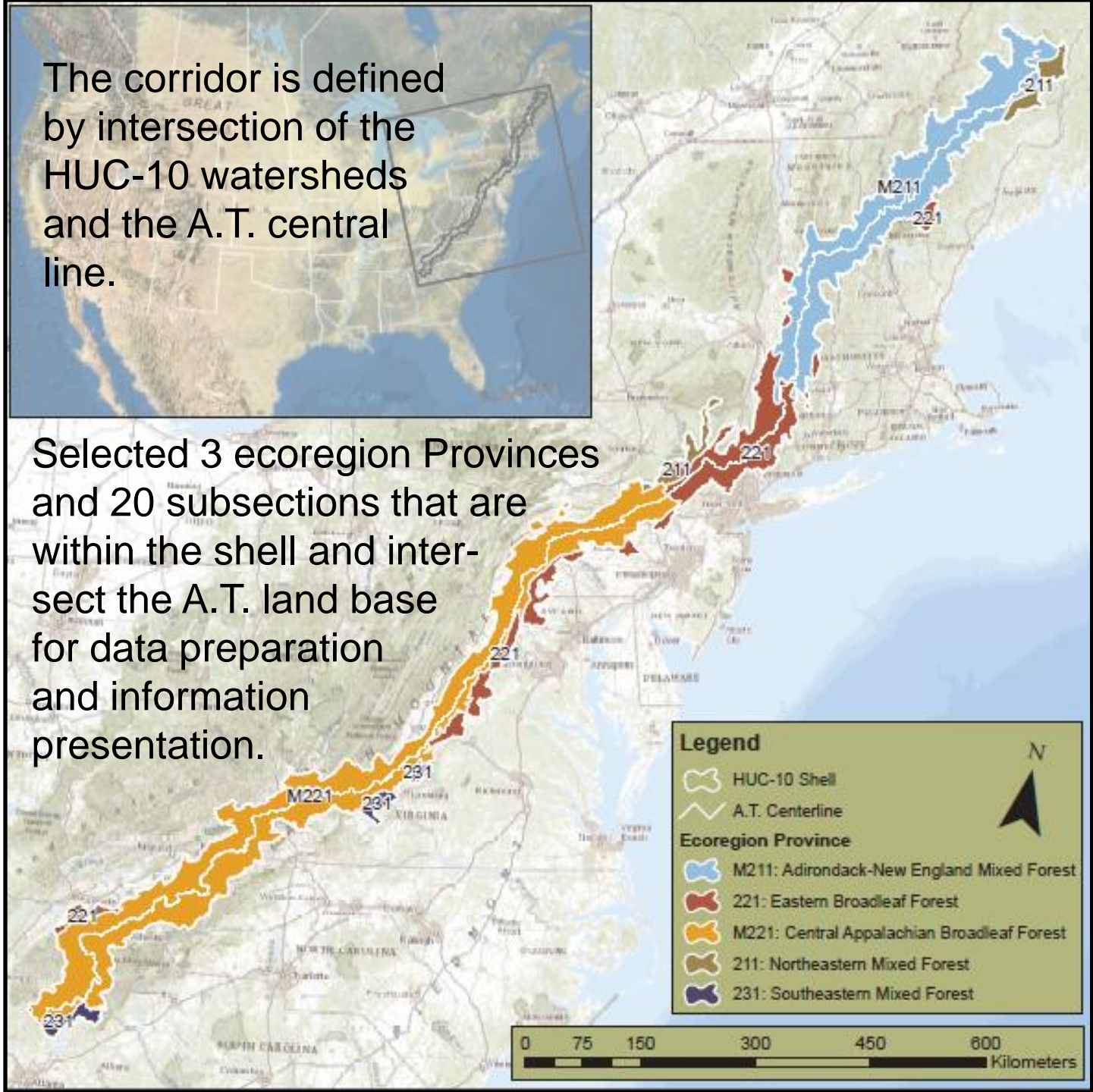
Appalachian Trail Vital Signs

1. Ozone
2. Visibility
3. Atmospheric Deposition
4. Migratory Breeding Birds
5. Mountain Birds
6. Forest Vegetation
7. R.T.E. Species
8. Invasive Species
9. Visitor Usage
10. Alpine and High Ele. Vegetation
11. Landscape Dynamics
12. Phenology/Climate Change
13. Water Resources



The corridor is defined by intersection of the HUC-10 watersheds and the A.T. central line.

Selected 3 ecoregion Provinces and 20 subsections that are within the shell and intersect the A.T. land base for data preparation and information presentation.



Seamless data for vital signs (*forest health, landscape dynamics and LCLUC, phenology and climate change*)

- MODIS Data Products

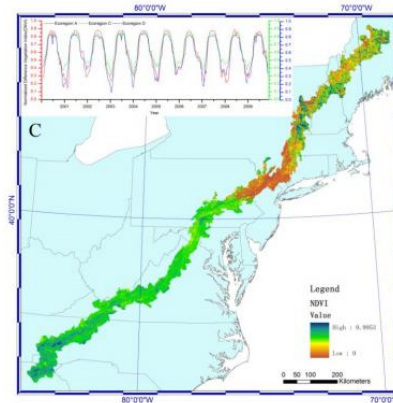
- Landcover Dynamics (MOD12Q2): 2001-2011
- Snow Cover 8-days (MOD10A2): 2000 - 2011
- Land Cover Type (MOD12Q1): 2001 - 2004
- Vegetation Indices (MOD13A2): 2000 - 2011
- Leaf Area Index FPAR (MOD15A2): 2000-2011
- NDVI (MOD13Q1): 2000 - 2009
- Land Surface Temperature (MOD11A2): 2000-2011

- GIMMS (Global Inventory Modeling & Mapping Studies) NDVI (8-km): 1981-2009

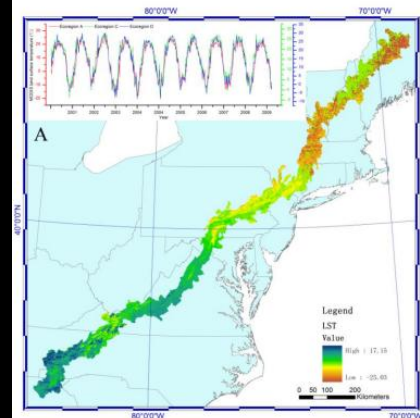
- NACP (North American Carbon Program) Modeled Carbon Flux (1-km): 1982-2006

- SOGS (Surface Observation and Gridding System) Metrological Data (1-km) from 1976-2008

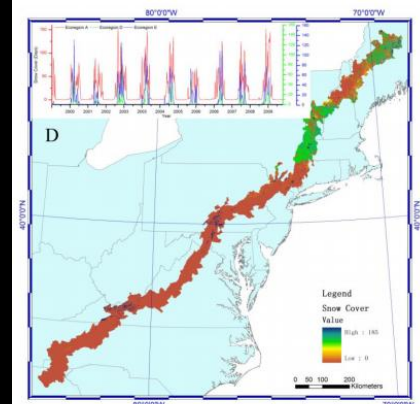
NLCD, LANDFIRE, NED, NWI, ...



NDVI



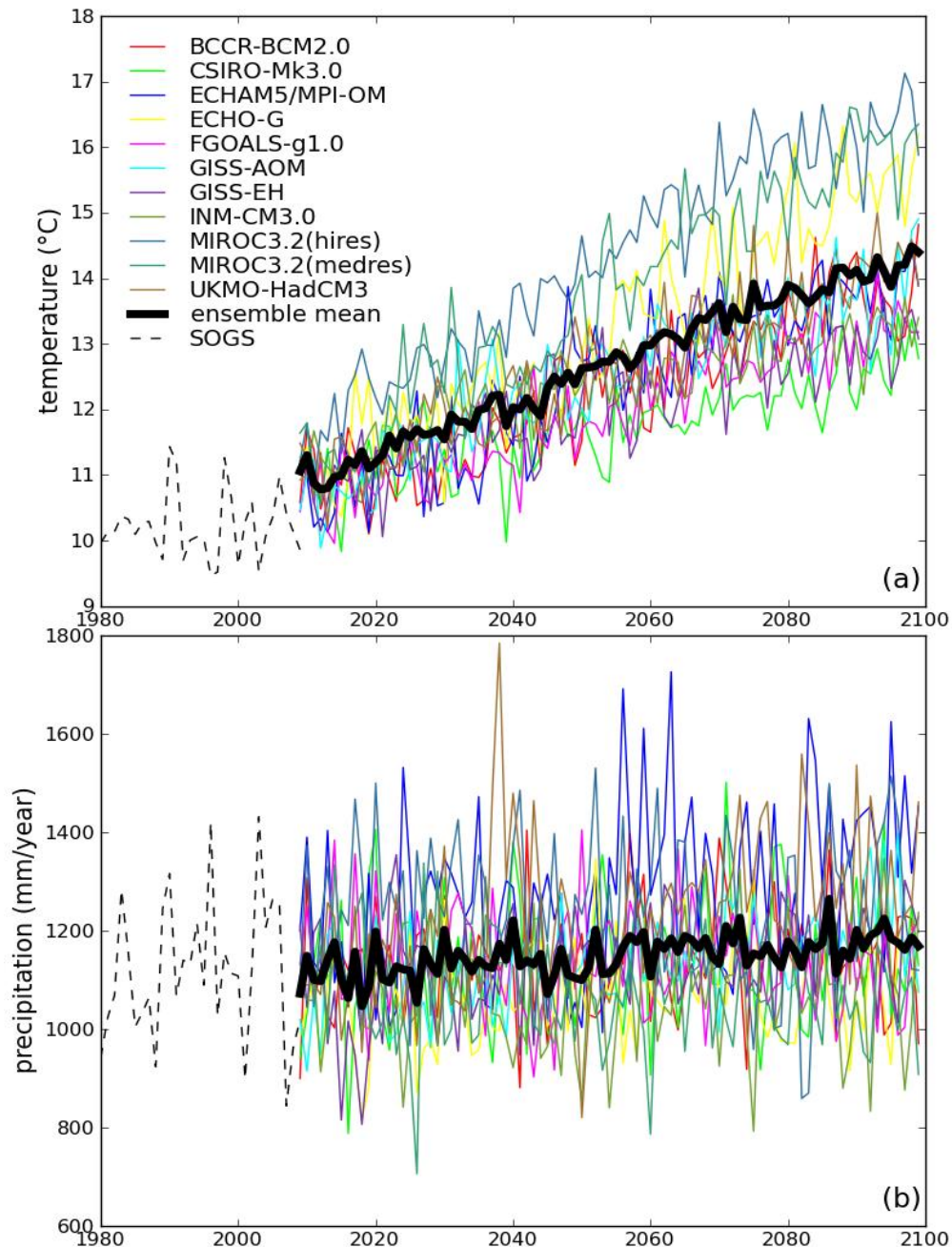
Land Surface Temp



Snow Cover

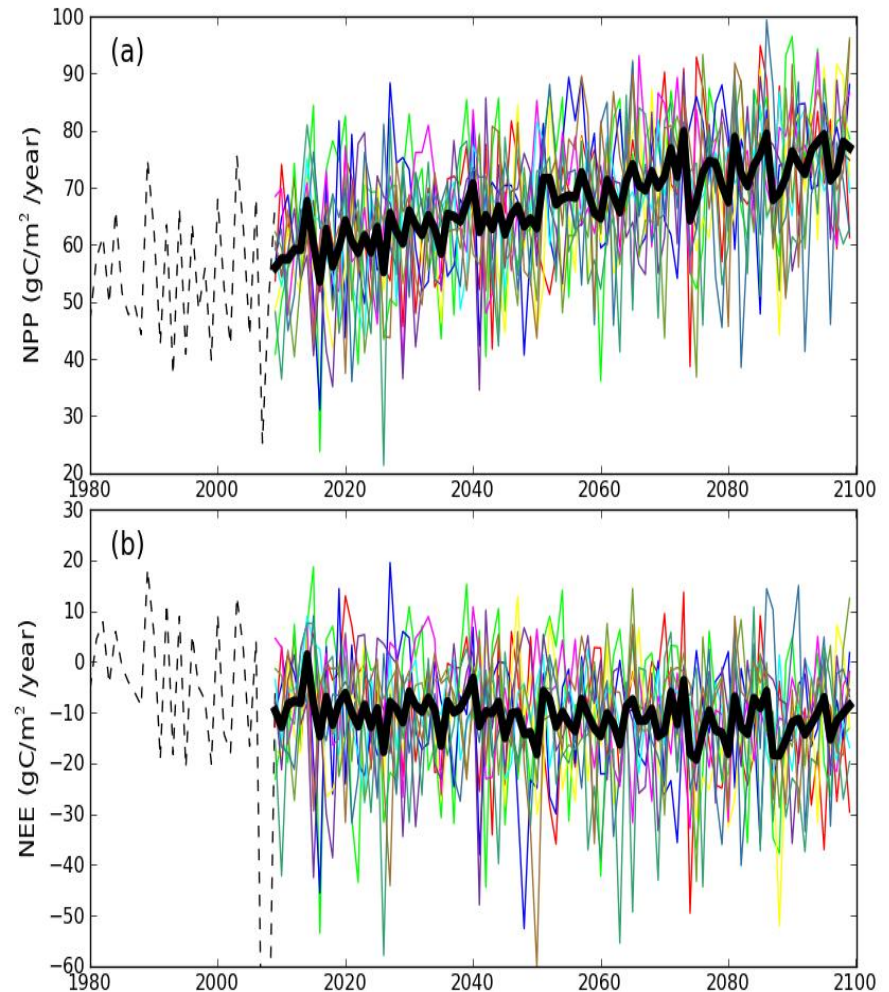
Climate Projection

- All models project steady temperature increase, ensemble mean shows an increase from 11°C to 14.5°C.
- No significant trend in precipitation.

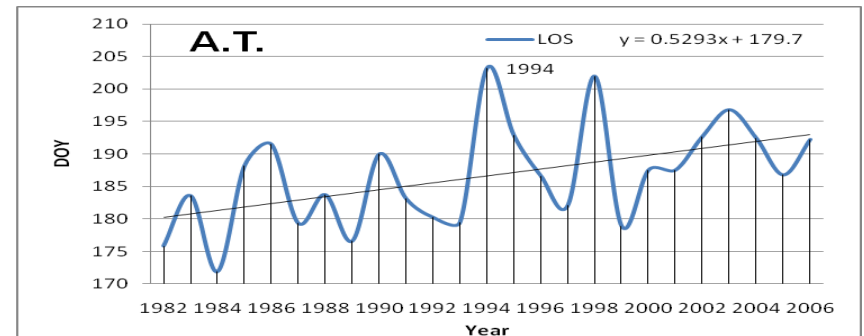
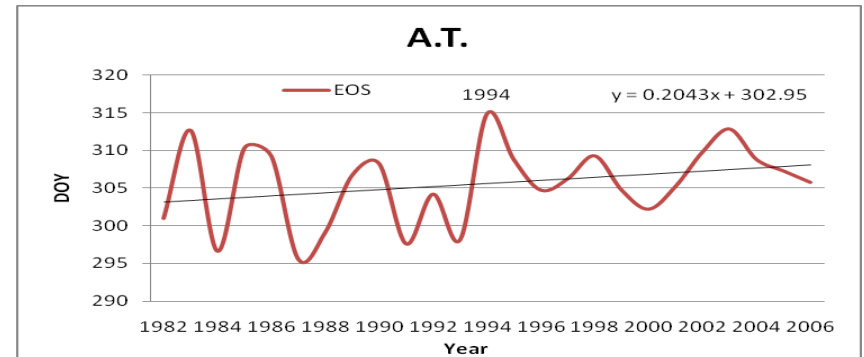
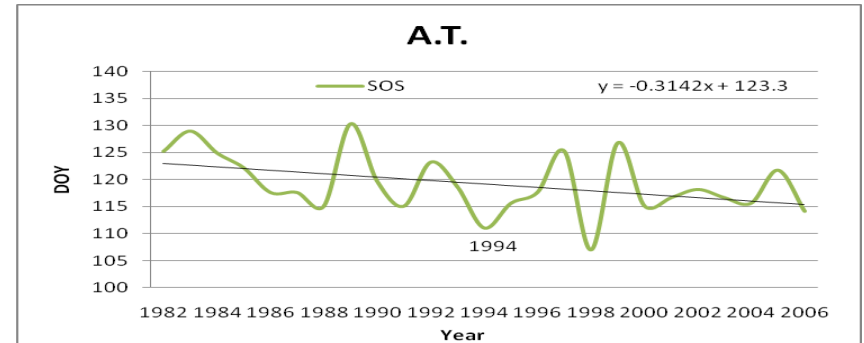
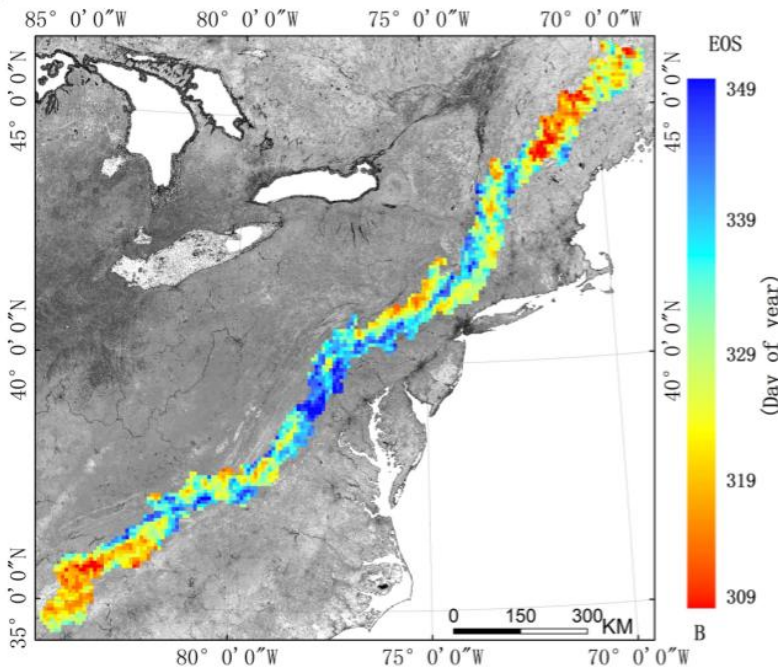
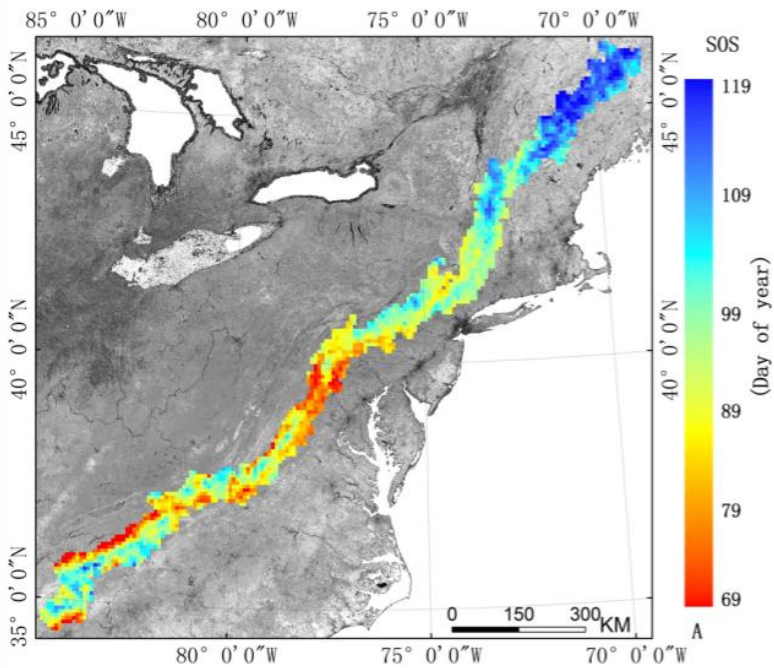


Vegetation Response to Projected Climate Change

- Increase in NPP attributable to CO₂ fertilization effect.
- NEE is constant at -10 gC/m²/yr (Carbon source).

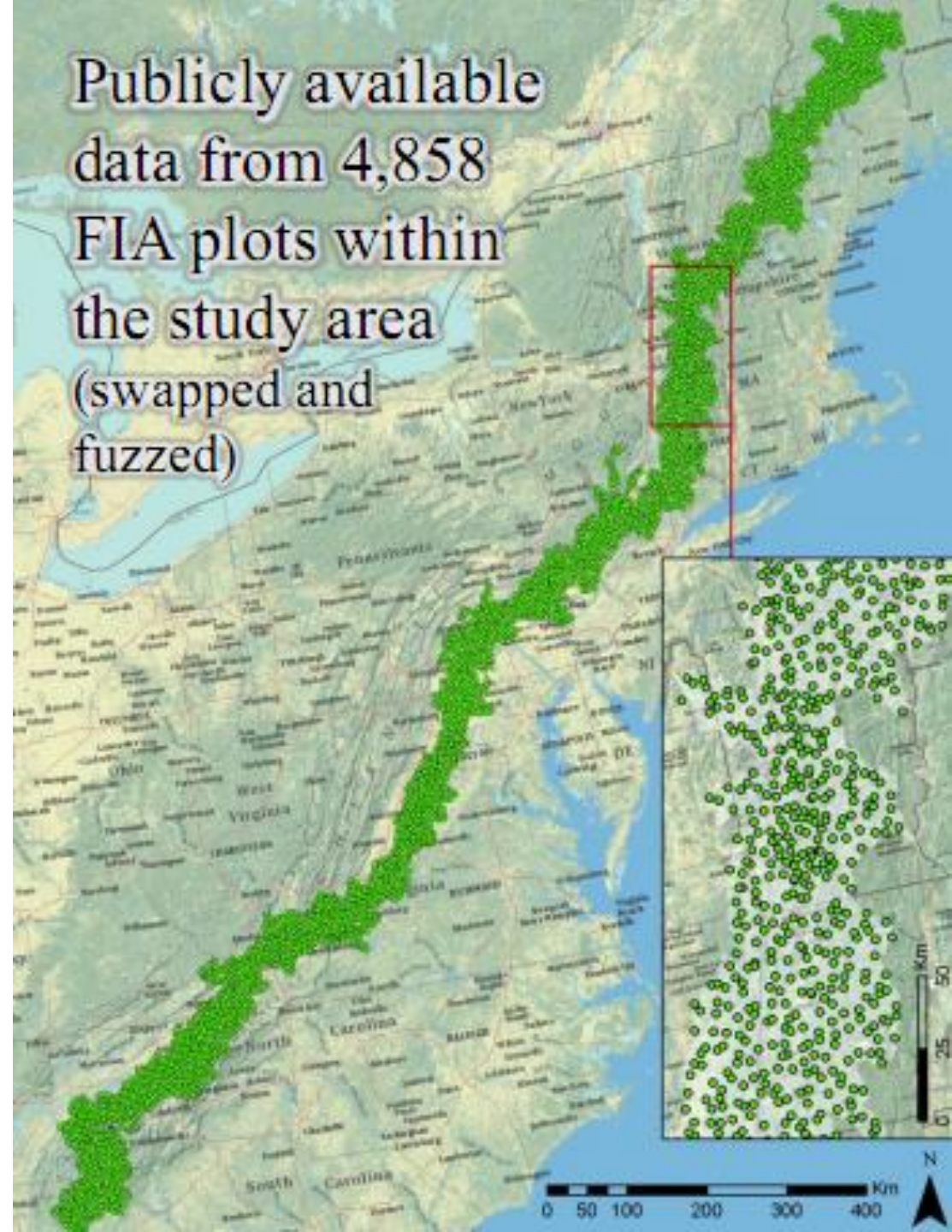


Spatial Distribution and Trend of Land Surface Phenology



Ground-based Monitoring and Integration of *in situ* and TOPS Data

- Used existing USDA Forest Service's FIA data as the *in situ* measurements
- Collected field data from selected segments

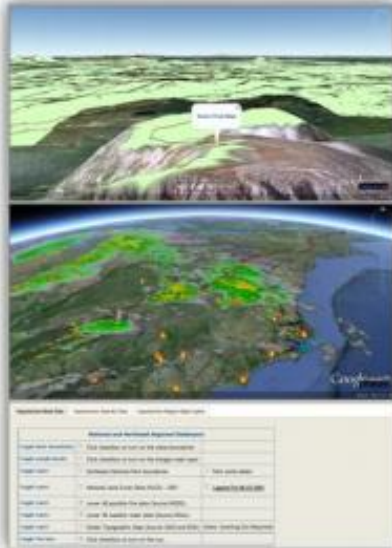


Internet-based A.T.-DSS

A system for implementation, dissemination, visualization, mapping, data sharing, and facilitating collaboration in decision support and public understanding of the A.T. environment.

<http://www.edc.uri.edu/ATMT-DSS/>

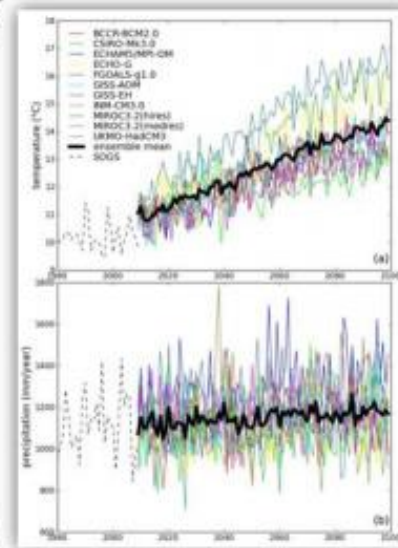
Viewsheds & Monitoring



Mapping Viewer



Report & Forecast



Data Download

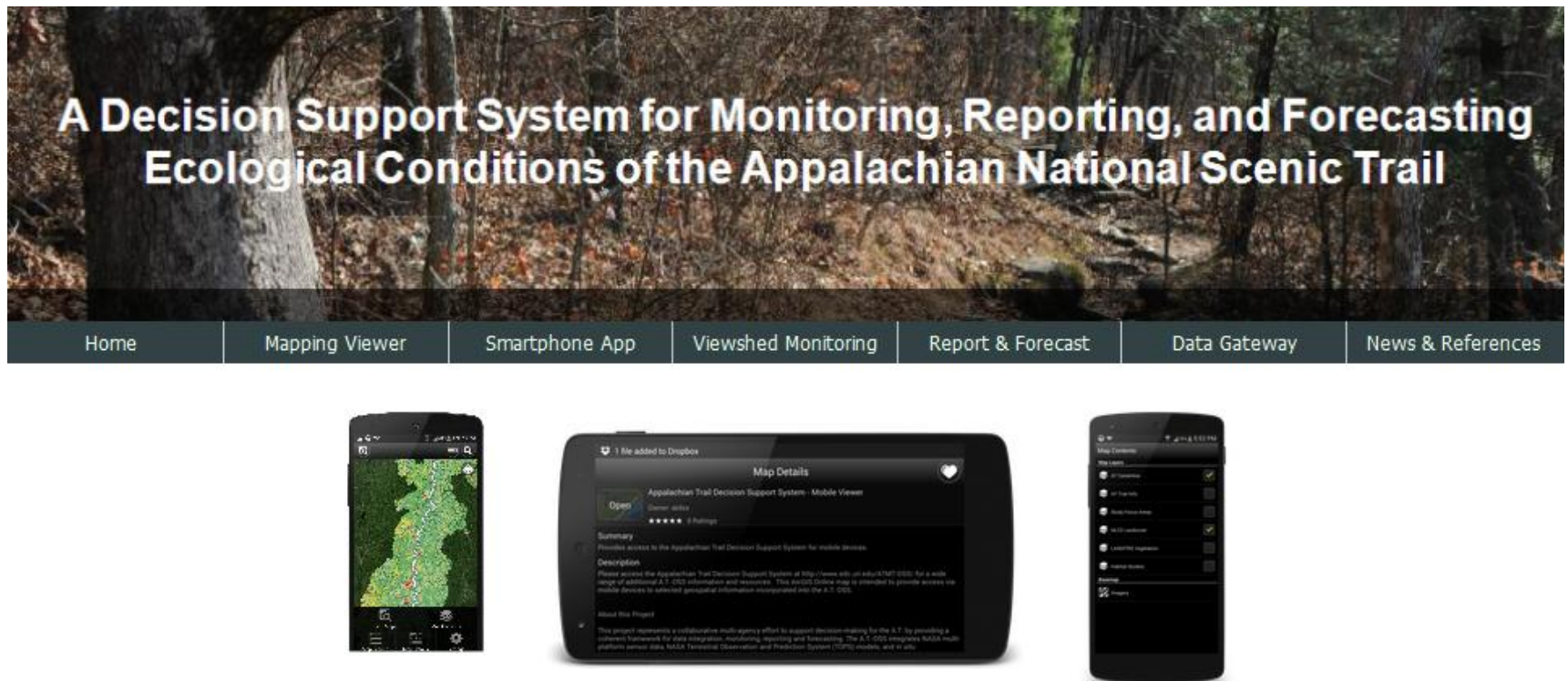


TOPS Data: MODIS Products, GIMMS, NACP, SOGS ...
A.T. Geospatial Data: HUC-10 Shell, NED, NWI, NLCD, LANDFIRE ...



Mapping Viewer for Mobile Devices

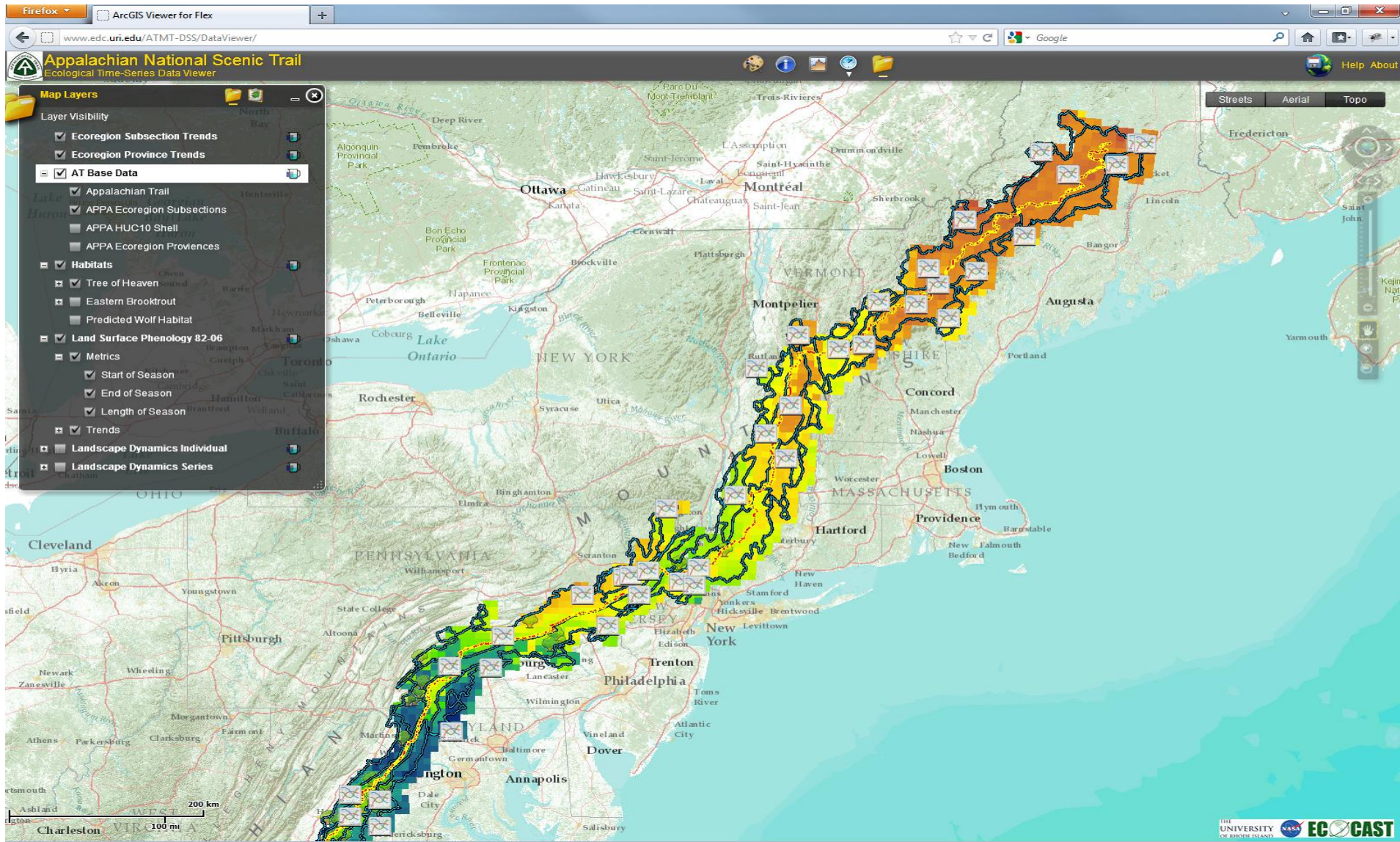
The A.T.-App allows users to access A.T.-DSS geospatial information from a mobile device. Simply [install the free ArcGIS app](#) on your Droid or iOS device and navigate to the [link provided](#).



The A.T.-App allows users to access A.T.-DSS geospatial information from a mobile device. Simply [install the free ArcGIS app](#) on your Droid or iOS device and navigate to the [link provided](#). Please note that the data provided are NOT suitable for navigation. See the [Appalachian Trail Conservancy](#) for the latest trail and safety information. Hike safe!

1.) Install the ArcGIS App for Smartphones & Tablets

An interactive mapping tool that capitalizes on the latest technology and was developed using the ArcGIS viewer for Flex. The software is fully customizable and allows users to develop new visualization and analysis.



Summary for each subsection with calculated dashboard information

Example of Subsection 211Aa: Arrostool Hills

This section is a glacially scoured and dissected peneplain; terrain is gently rolling and pitted outwash plain with scattered low mountains. Bedrock consists of weakly metamorphosed sedimentary formations of shales, sandstones, and limestones. Vegetation is mainly forests of spruce-fir and maple-beech-birch cover types.



Subsection 211Aa: Arrostool Hills

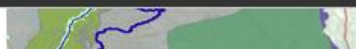
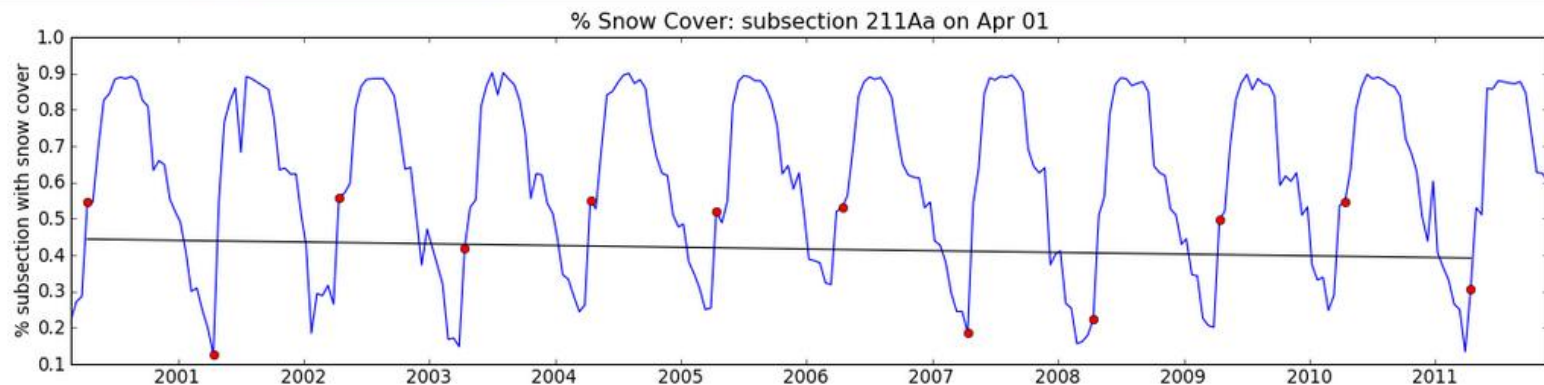
Area (Hectares): 10233

Annual GPP: MODIS Total Annual GPP

GPP: MODIS GPP

Phenology: Start of Season, MODIS NDVI

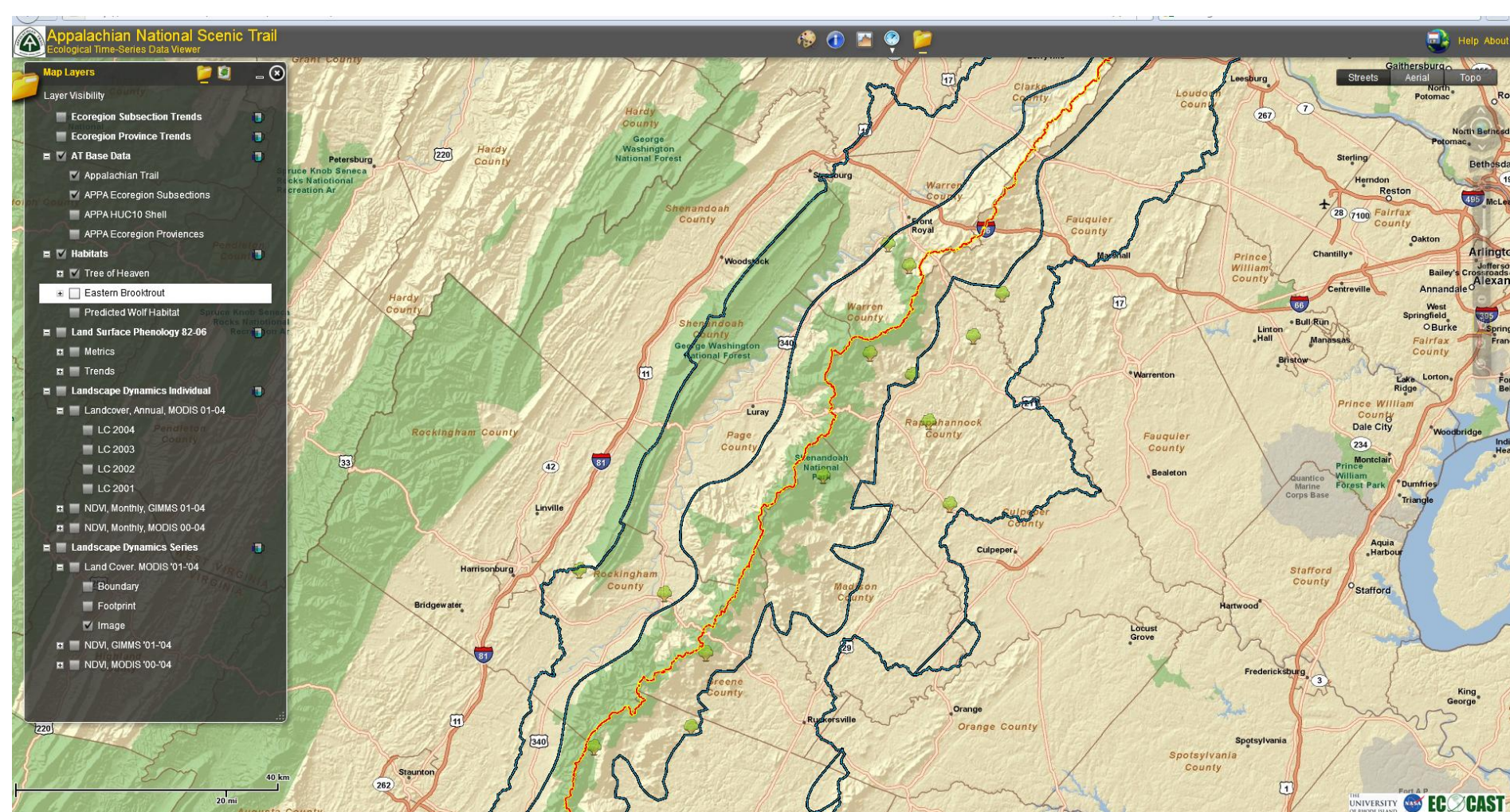
Snow Cover: [% Snow Cover on April 01](#)



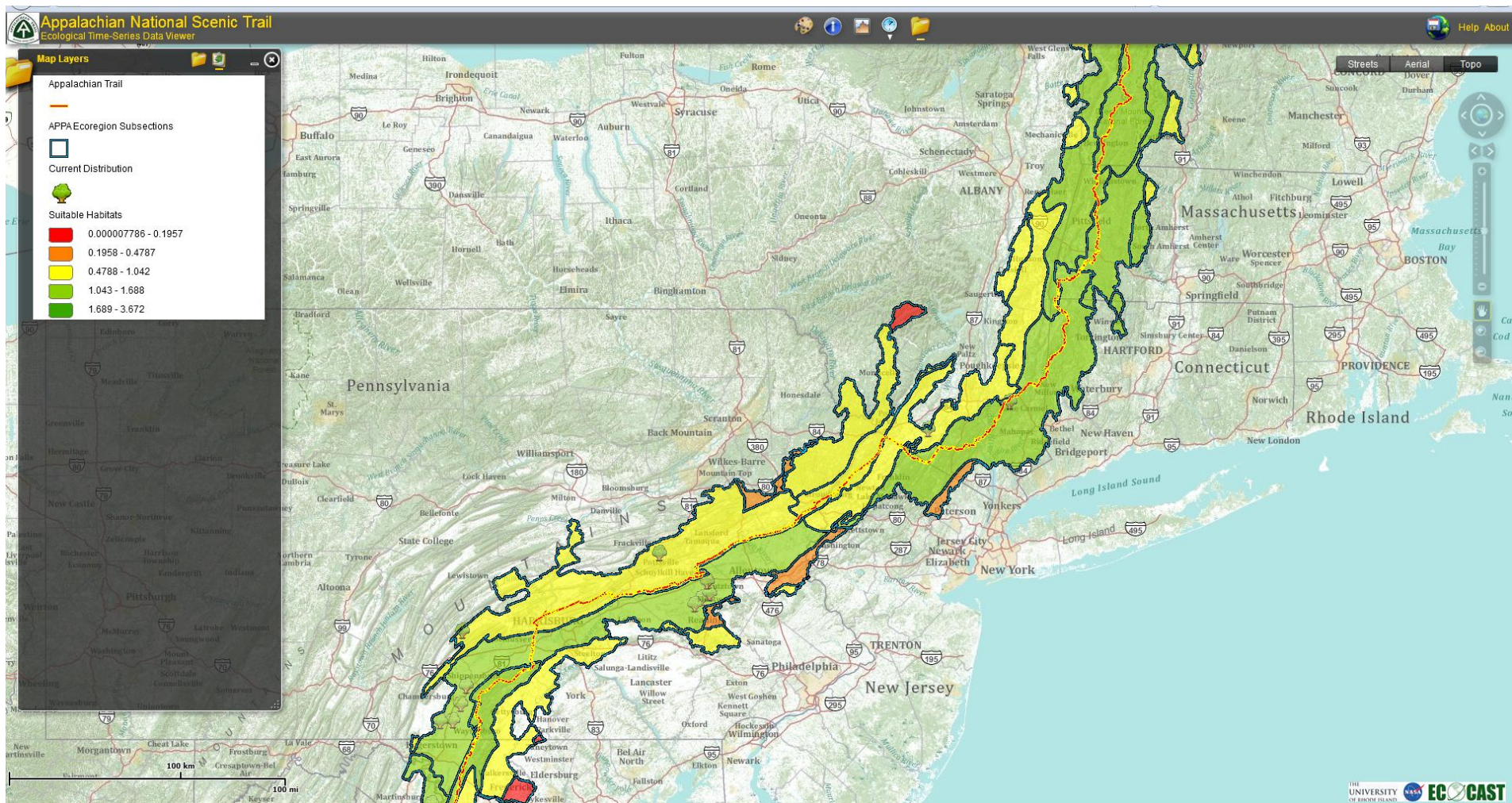
Subsection 211Bb: Central Maine Foothills

Subsection 211Bb: Maine-New Brunswick

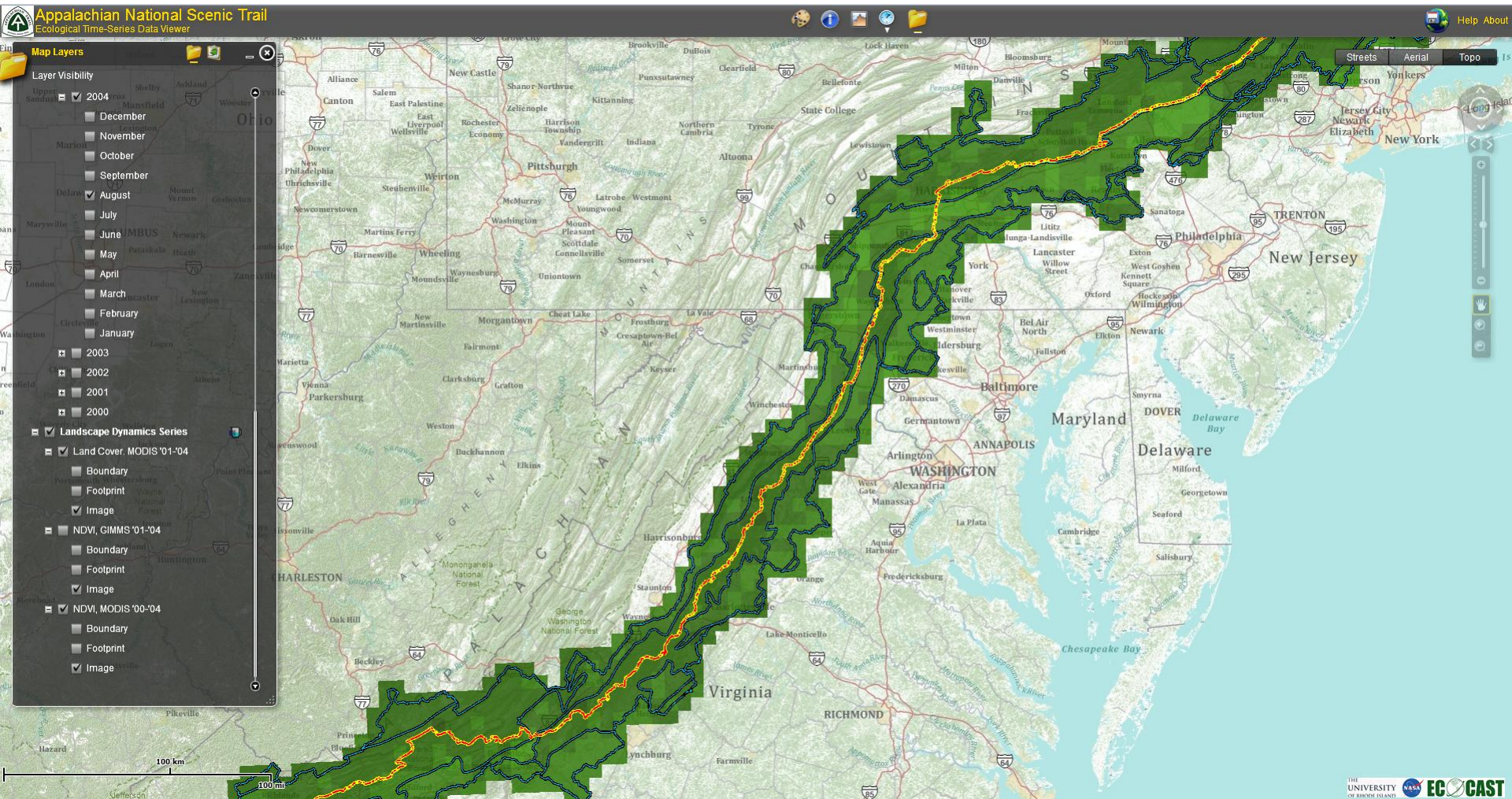
The **Mapping Viewer** is an interactive mapping tool that capitalizes on the latest technology and was developed using the ArcGIS viewer for Flex. The software is fully customizable and allows users to develop new visualization and analysis.

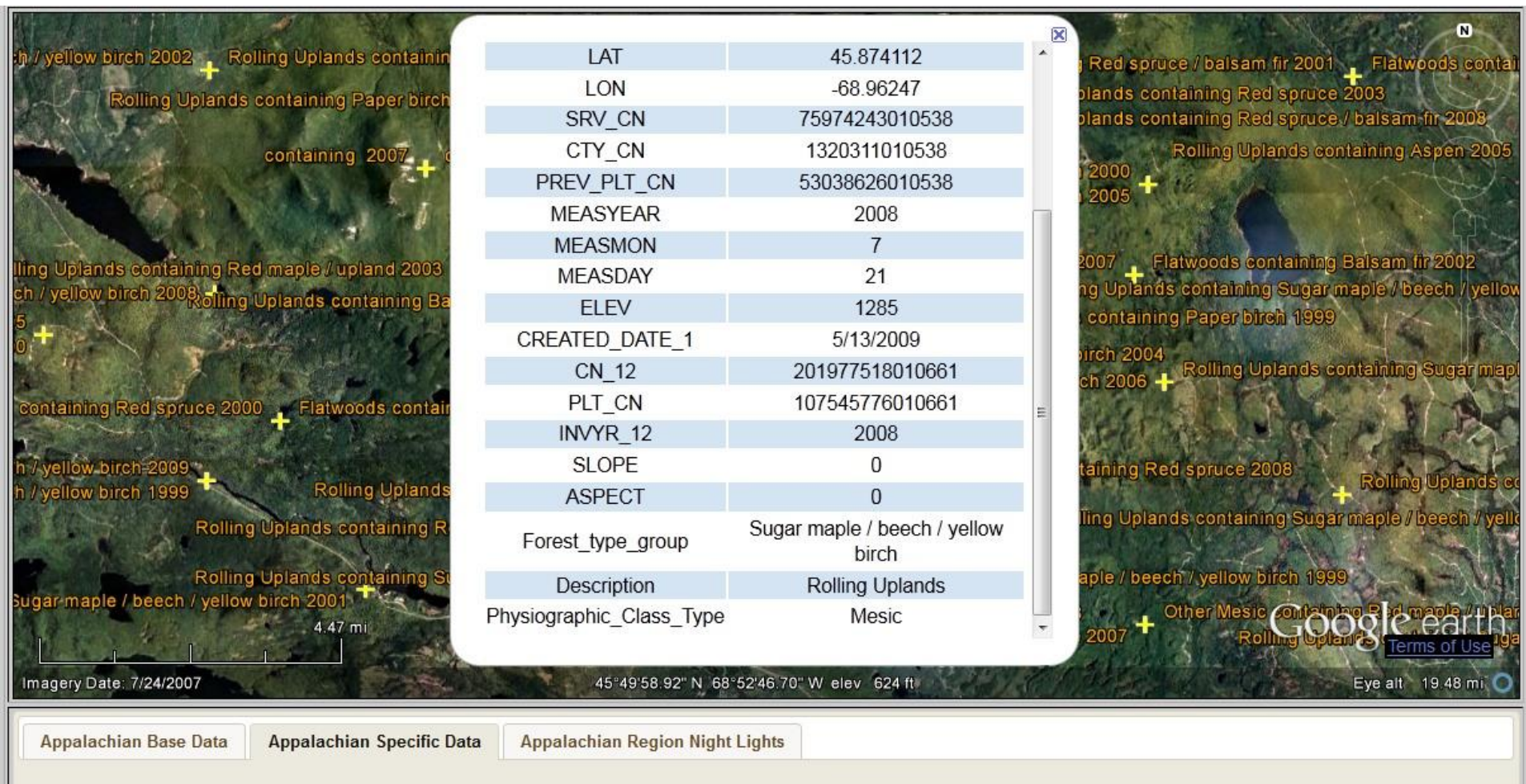


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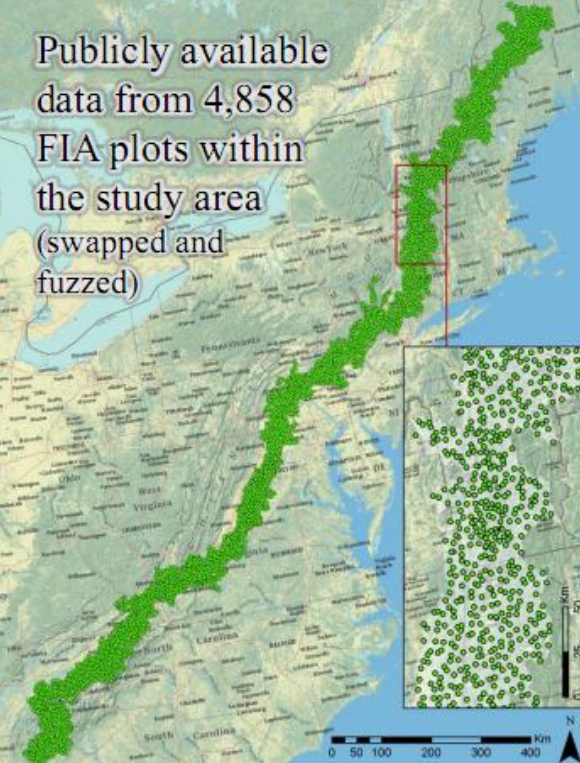
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We developed an Internet-based visualization tool/interface for examining FIA plots data and in connection with NASA data and modeling derivatives.

Publicly available
data from 4,858
FIA plots within
the study area
(swapped and
fuzzed)



Rolling Uplands containing Red spruce 2002

ple / beech / yellow birch 2006

Rolling Uplands containing Sugar maple / beech / yellow birch 2009

birch 2008

Rolling Uplands containing Sugar maple / beech / yellow birch 1999

containing Red spruce / balsam fir 2001

Flatwoods containing Red spruce / balsam fir 2006

Rolling Uplands containing Red spruce / balsam fir 2008

Rolling Uplands containing Paper birch 2004

Dry Slopes containing Paper birch 1999

birch 2009

Rolling Uplands containing Sugar maple / beech / yellow birch 2009

Rolling Uplands containing Sugar maple / beech / yellow birch 2006

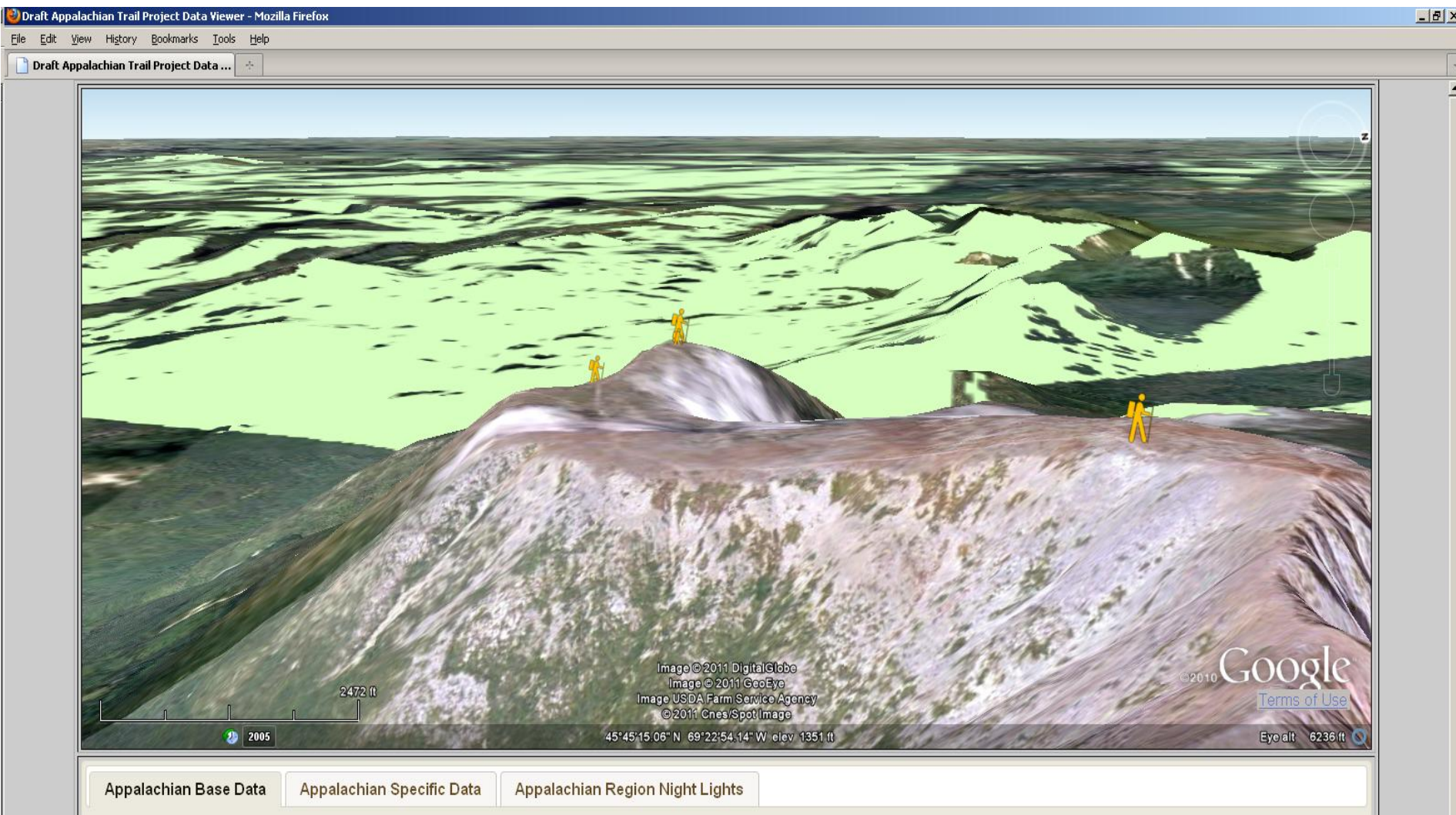
ing Sugar maple / beech / yellow birch 2010

Image USDA Farm Service Agency

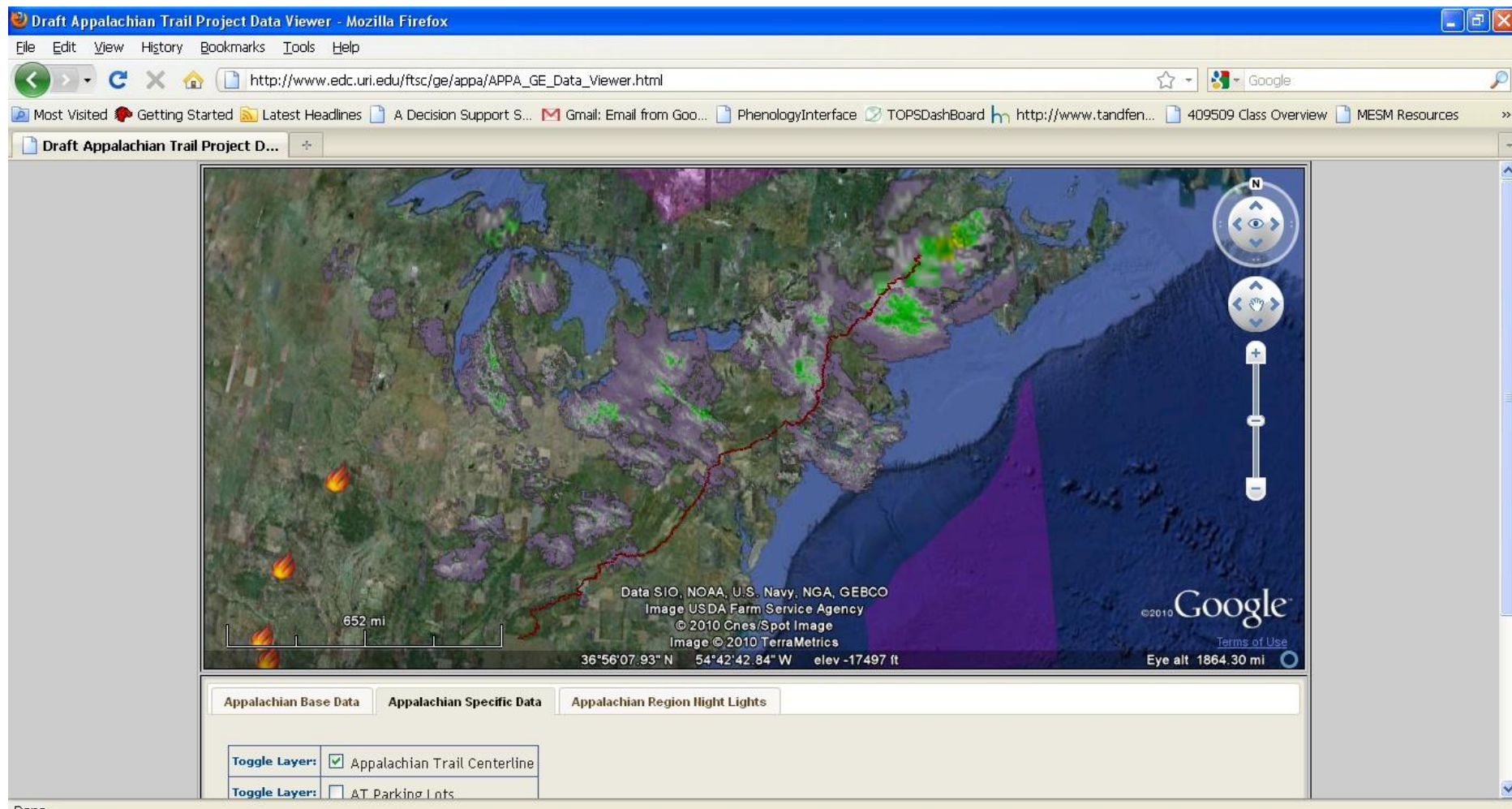
©2010 Google

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Under the Google Earth plugin, the *Viewshed* toolset allows users to investigate the viewsheds of vistas along the trail for visualizing landscape patterns with land cover types.



The *Viewshed* toolset takes full advantage of real-time display capabilities to inform the system users of current conditions within the trail region. Examples of applicable data include current weather (NOAA) and possible fires (MODIS).



The ***Data Downloading*** is the interface to allow users to select and download seamless geospatial and remote sensing data.

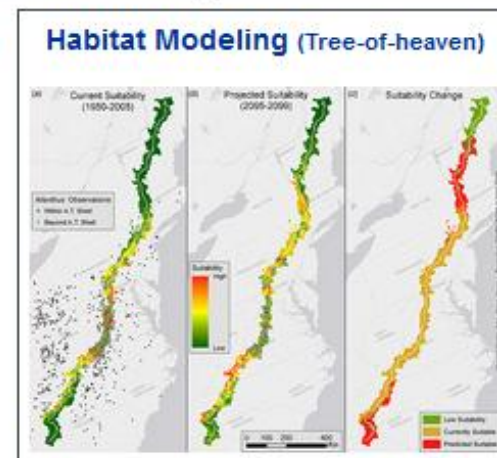
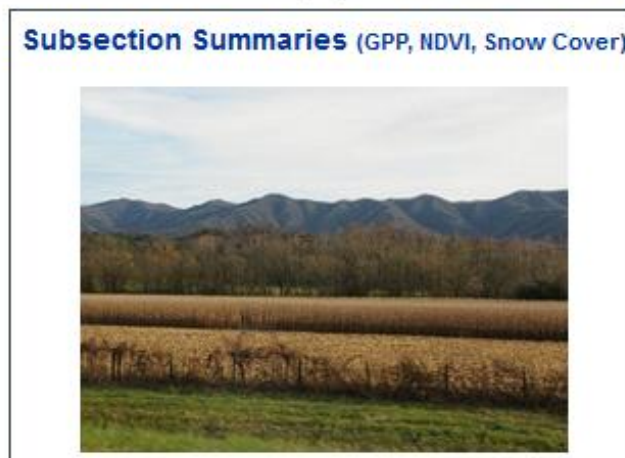
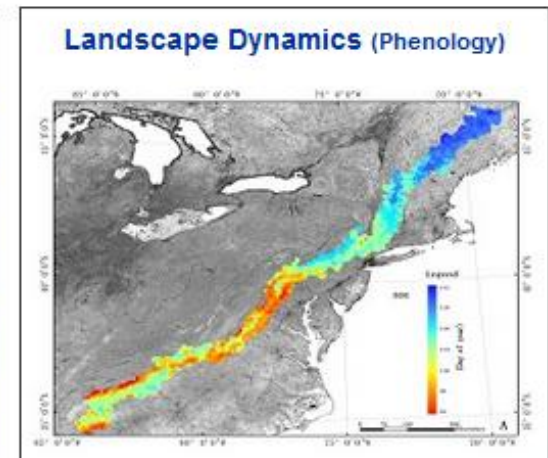
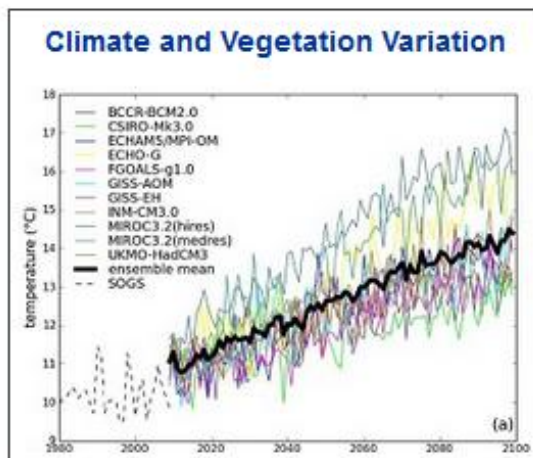
A.T. Geospatial Data

[Return to Top](#)

Preview	Title	Description	Type	Date	Metadata	Download
	A.T. Centerline	This data set represents the most current depiction of the Appalachian National Scenic Trail centerline. Source: Appalachian Trail Conservancy		02/2013		at_centerline.zip
	A.T. HUC-10 Shell	The A.T. HUC-10 shell was adopted to provide an ecologically relevant area of interest for the A.T.-DSS. It was established by selecting all HUC-10 level watersheds that are within 5 statute miles of the A.T. land base. Source: U.S. National Park Service		03/2003		at_shell.zip
	A.T. Watersheds	This data set contains the boundaries of all HUC-10 level watersheds within 5 statute miles of the A.T. land base. Source: U.S. Geological Survey		03/2010		at_huc10.zip
	A.T. Ecological Regions	This data set delineates ecological sections and subsections along the A.T. for the analysis of ecological relationships across ecological units. Source: U.S. Forest Service		03/2010		at_ecoregions_usfs.zip
	A.T. Elevation	This high resolution elevation data for the A.T. shell is a mosaic of seamless National Elevation Dataset (NED) tiles. Source: U.S. Geological Survey		08/2010		Contact project team
	A.T. Wetlands	This data set represents the extent, approximate location, and type of wetlands and deepwater habitats in the area surrounding the Appalachian Trail. Source: U.S. Fish & Wildlife Service National Wetlands Inventory		09/2009		Contact project team
	U.S. State	This map layer portrays the State boundaries of the United States, and the boundaries of Puerto Rico		06/2005		state_boundaries.zip

The **Reporting** is the interface to provide the information about identified change and revealed trends of ecological conditions to provide early warning of impending threats and undesirable conditions and/or trends through integrated analysis and modeling output.

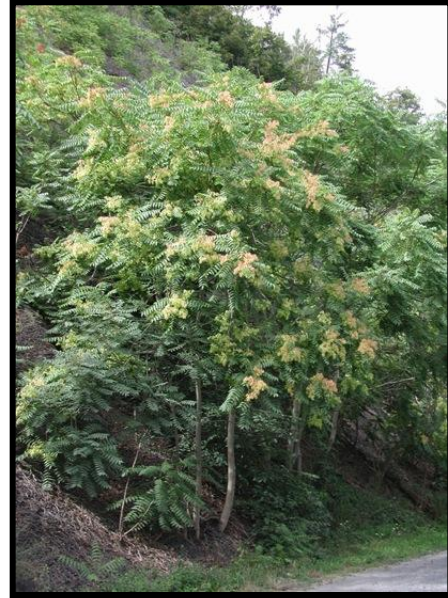
The Report & Forecast module summarizes the patterns and trends of key *Vital Signs* observed along the A.T. using TOPS, including: *Phenology and Climate*; *Forest Health*; *Landscape Dynamics*. Summaries of GPP, NDVI and Snow Cover are also provided for ecoprovince subsections within the A.T. HUC-10 shell.



Habitat suitability modeling - an Application Prototype (a species selected by users)

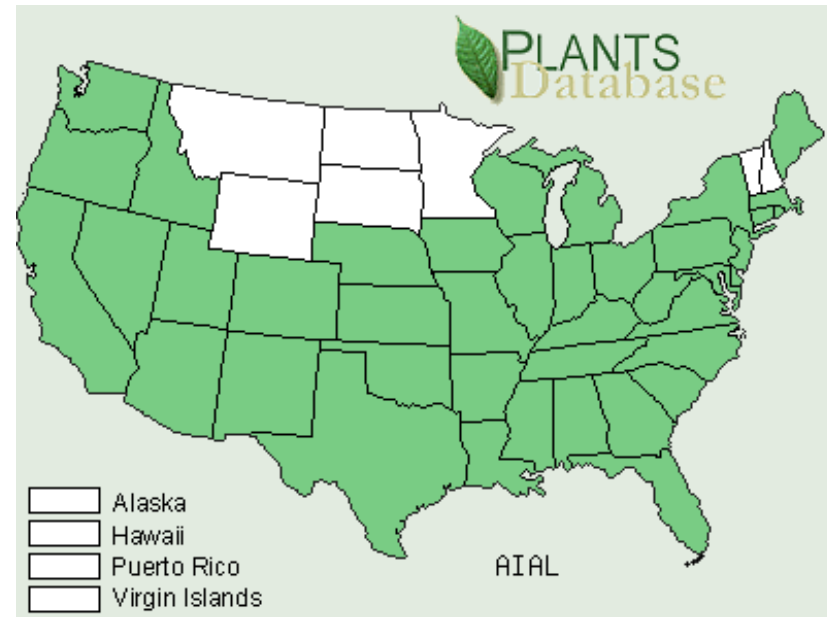
Tree of Heaven (*Ailanthus altissima*), a widespread fast-growing invasive species and a concern within the study area.

1. Relate the observed distribution of *Ailanthus* to a set of remote sensing observations and ecological and geographical variables.
2. Map the current distribution of suitable habitats and identify high-risk regions.
3. Integrate results from projected climate change scenarios to simulate potential shifts in the distribution of *Ailanthus* habitats.



Habitat Characteristics

- Climate
 - Temperate to subtropical
 - Humid to arid
 - Juvenile frost mortality
 - Drought tolerant
- Topographic
 - Lower elevations
 - Flood vulnerable
 - Hardy even in poor soils
- Land Use and Land Cover
 - Strongly associated with urban areas, transportation corridors, and agriculture
 - Shade intolerant

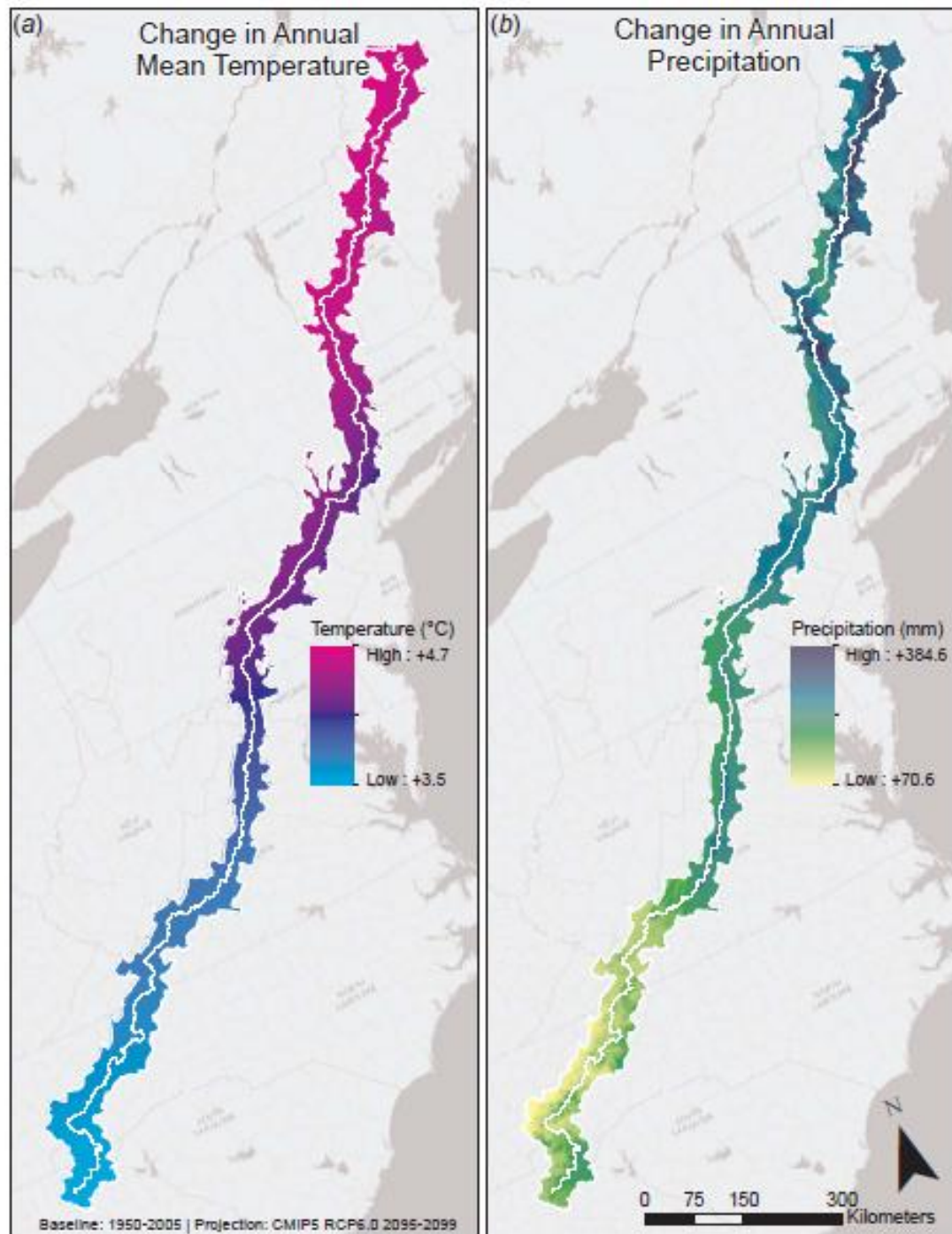


Where are they and the Current habitats?

- *Ailanthus* observed at 136 plots within the A.T. HUC-10 Shell area.



Distribution of changes in
(a) annual mean temperature
and (b) annual precipitation
from the 1950-2005 baseline to
the CMIP5 RCP6.0 2090-2095
climate projection.



One contribution of 9 to a Theme Issue ‘Satellite remote sensing for biodiversity research and conservation applications’.

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Research



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<http://dx.doi.org/10.1098/rstb.2013.0192>

Assessing current and projected suitable habitats for tree-of-heaven along the Appalachian Trail

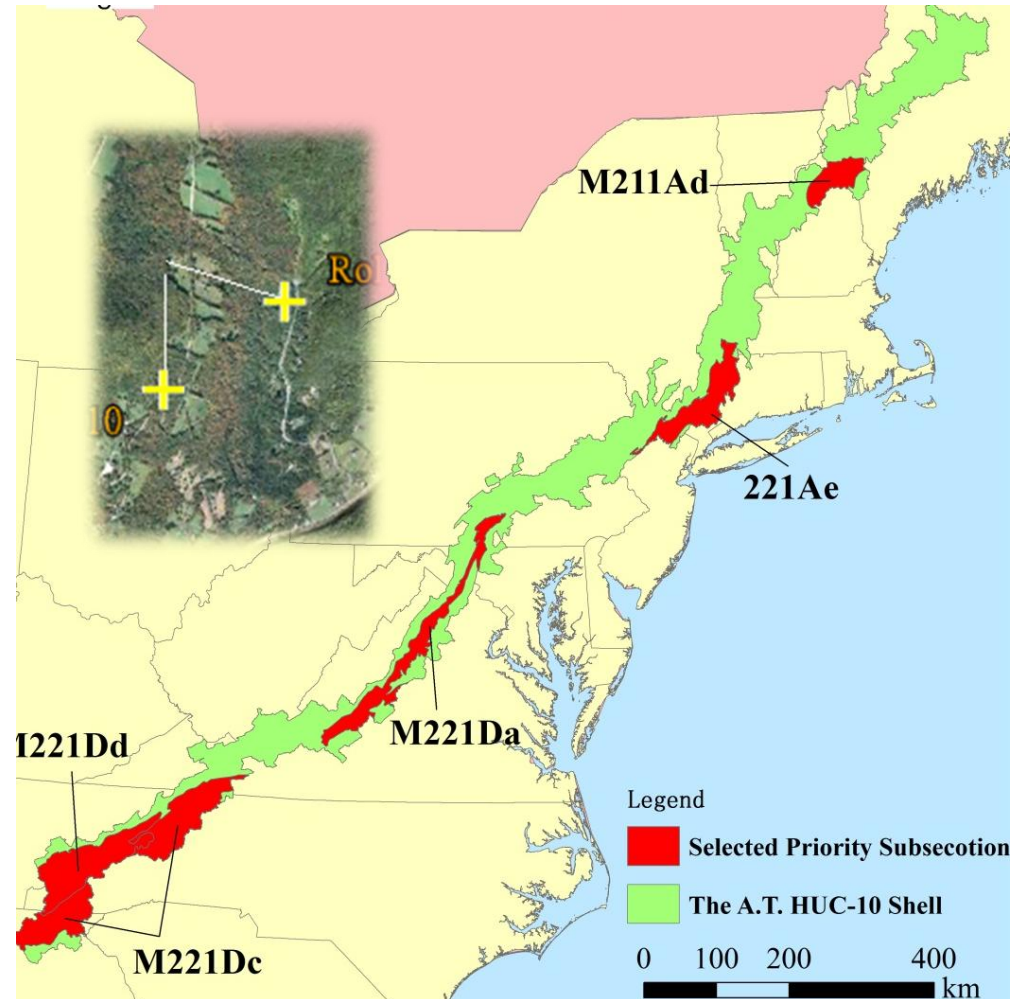
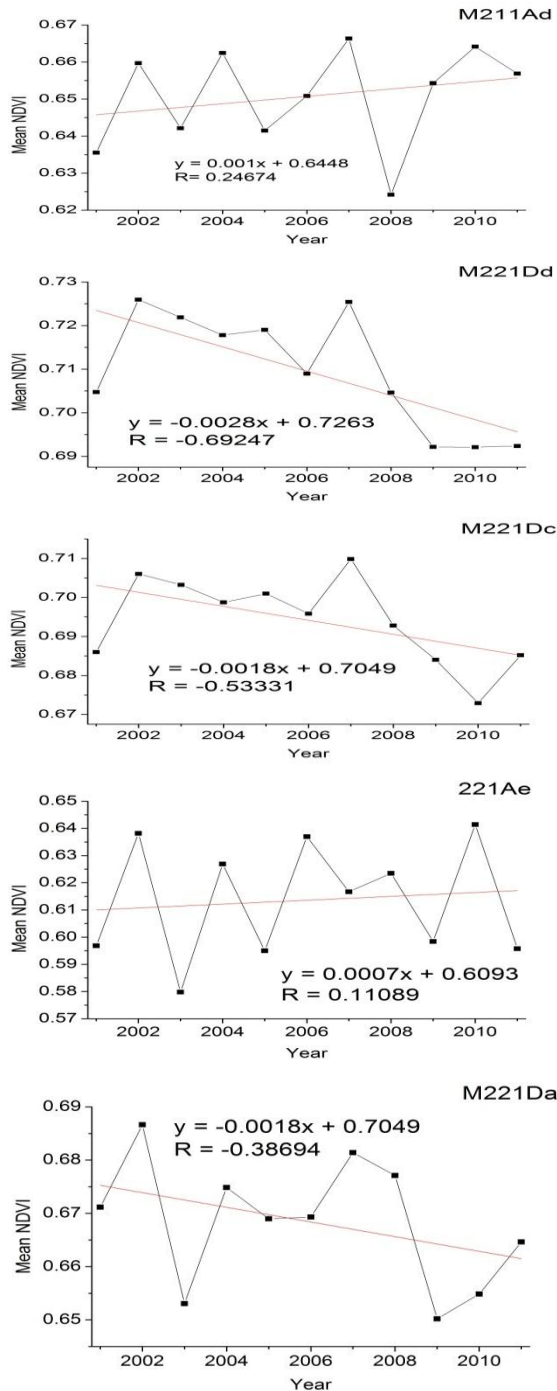
John Clark, Yeqiao Wang and Peter V. August

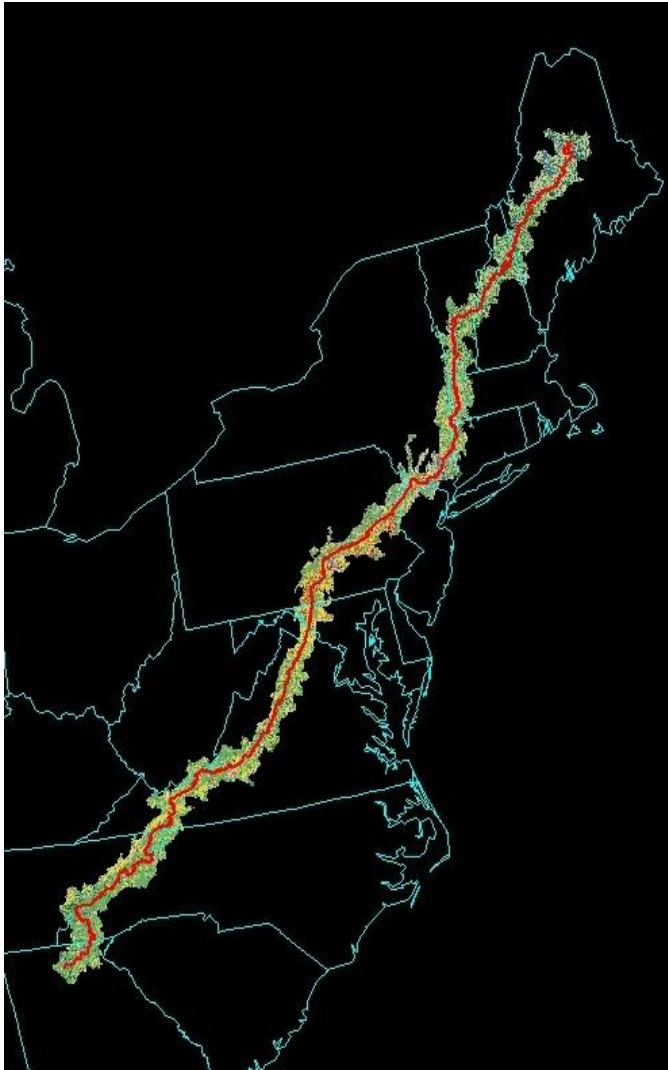
Department of Natural Resources Science, University of Rhode Island, Kingston, RI 02881, USA

The invasion of ecosystems by non-native species is a major driver of biodiversity loss worldwide. A critical component of effective land management to control invasion is the identification and active protection of areas at high risk of future invasion. The Appalachian Trail Decision Support System (A.T.-DSS) was developed to inform regional natural resource management by integrating remote sensing data, ground-based measurements and predictive modelling products. By incorporating NASA's remote sensing data and modelling capacities from the Terrestrial Observation and Prediction System (TOPS), this study examined the current habitat suitability and projected suitable habitat for the invasive species tree-of-heaven (*Ailanthus altissima*) as a prototype application of the A.T.-DSS. Species observations

Other examples of applications

Five subsections include 93% of very high priority areas for biodiversity conservation.





Remaining Issue

The major issue that the project has been facing is the post-project system transition due to the termination of a USGS facility which was planned as the hosting facility after the NASA funding. This unexpected termination of USGS facility due to the USGS reorganization and budget cut affect the delivery of project results.

We are in contact with USGS BISON (*Biodiversity Information Serving Our Nation*) program and National Phenology Network (NPN) in exploring possibilities for hosting the system transition.